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Differential Diagnosis of Exercise-Induced Laryngeal Obstruction and Exercise-Induced Asthma

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Murray State University Honors College

HONORS THESIS

Certificate of Approval

Differential Diagnosis of Exercise-Induced Laryngeal Obstruction and Exercise-Induced Asthma

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Differential Diagnosis of Exercise-Induced Laryngeal Obstruction and Exercise-Induced Asthma

Submitted in partial fulfillment

of the requirements

for the Murray State University Honors Diploma

Allison Lyman

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Senior Honors Thesis Prospectus -- Proposed Study Abstract

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Sensations of shortness of breath and difficulty breathing are not uncommon, especially among athletes and those who regularly engage in aerobic activities. Often, athletes will seek treatment for their respiratory symptoms and may be diagnosed with exercise-induced asthma. Doctors prescribe inhalers to these individuals to help alleviate their symptoms; however, there are occasions in which inhalers fail to lessen the severity of breathing difficulties. This is because asthma is not the only condition that can cause shortness of breath, also known as dyspnea. There exists another condition which affects the vocal folds but not the lungs and bronchioles as is seen in the case of asthma. This condition, which is often misdiagnosed as asthma, is known as exercise-induced laryngeal obstruction (EILO). EILO occurs when an individual's vocal folds approximate in adduction, therefore closing off the airway and preventing inhalation of adequate oxygen. Characteristics of EILO include difficulties breathing during exercise, an audible stridor, and tightness in the neck and throat. EILO does not respond to steroid inhalers and has a different etiology than exercise-induced asthma. For this reason and for the benefit of all who experience difficulties as a result of exercise, doctors should rule out EILO before prescribing an inhaler that may yield no benefits for its user. It is essential that doctors be able to differentiate between exercise-induced asthma and EILO so that they can provide the proper therapies and treatments to their patients or clients.

The various forms of testing and treatments for EILO will be examined through a literary review. This literary review will also draw attention to the many differences between EILO and exercise-induced asthma that are vital to the process of differential diagnosis. Articles written by doctors, speech-language pathologists, audiologists, and other professionals on the matter will be compared in order to demonstrate the best possible means of diagnosis and forms of treatment for individuals with EILO.

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Introduction

Shortness of breath, also known as dyspnea, is a common complaint among athletes, particularly those who engage in intense aerobic activities. This symptom can stem from a variety of etiologies, the most common being exercise-induced asthma. Often, dyspnea is treated with corticosteroid inhalers when a physician determines that the cause of this symptom is asthma (Çil, B., Kabak, M., Topçu, A.F., Taylan, M, & Sezgi, C., 2019). Problems sometimes arise, however, when physicians do not fully investigate other possible causes of breathing difficulties before arriving at their diagnosis. Another prevalent ailment that can inhibit respiration in athletes is known as exercise-induced laryngeal obstruction (EILO). In order to ensure the best possible treatment for all individuals, it is essential that medical professionals know how to differentiate between asthma and EILO, both of which often result in similar symptoms.

Exercise-induced laryngeal obstruction (EILO) occurs when the vocal folds in the larynx adduct abnormally upon inspiration which results in obstruction of the airway (Abdel-Hamid, 2018). This may lead to dyspnea, an audible stridor, coughing, and/or choking sensations during exercise (Marcinow, Thompson, Chiang, Forrest, & Desilva, 2014). The panic-inducing symptoms associated with EILO are known to have a negative impact on an active individual or athlete's physical performance during exercise. For this reason, accurate diagnosis of EILO is imperative in order to ensure that each individual receives the treatment necessary to improve his or her quality of life.

In order to ensure the most accurate diagnosis for individuals with dyspnea, medical professionals should be prepared to perform a variety of tests. Since asthma is the most common cause of dyspnea, close examination of the lungs and bronchioles should be performed; however,

even if irregularities are seen in these respiratory structures, it is imperative that doctors examine each individual's larynx to ensure that there are no abnormalities in vocal fold function that may also be contributing to the dyspnea (Olin, 2019). One study found that as many as 56% of individuals with EILO also have exercise-induced asthma (Tilles, Ayars, Picciano, & Altman, 2013). Since the two conditions are known to coexist, doctors should also perform continuous laryngoscopy during exercise (CLE) so that the vocal folds can be monitored during periods of intense physical activity. CLE allows medical professionals to identify any abnormal adduction and can thus allow them to diagnose EILO (Olin, 2019).

The purpose of this research was to investigate barriers to differential diagnosis of EILO as found in current literature. This review examined a variety of diagnostic techniques as well as treatment options that can be used to lessen the severity of or eliminate dyspnea associated with EILO. The consequences of prescribing unnecessary medications due to erroneous diagnosis were also discussed to further encourage medical professionals to utilize multiple means of diagnostic techniques in order to improve the accuracy of their diagnoses.

Literature Review

What is Exercise-Induced Laryngeal Obstruction?

Exercise-induced laryngeal obstruction (EILO) is characterized by an abnormal adduction or closure of the vocal folds in the larynx upon inspiration during periods of intense exercise (Abdel-Hamid, 2018). This results in some degree of obstruction in the upper respiratory tract which inhibits an individual's ability to breathe during aerobic activities. The symptoms associated with this ailment include but are not limited to a harsh stridor upon inspiration, shortness of breath, and hyperventilation (Liyanagedera McLeod, & Elhassan, 2017). In some individuals, these symptoms are relatively mild; however, others may experience severe EILO that can result in syncope (Olin et al., 2015). Many of these symptoms are also commonly observed in individuals who suffer from exercise-induced asthma. The similarities between EILO and asthma make it difficult for medical professionals to successfully determine the etiology of an individual's dyspnea. This, in turn, creates a dilemma when it comes to accurate diagnosis and differentiation between EILO and asthma.

Laryngeal obstruction in general has a multitude of inducers; however, this literature review will focus on laryngeal obstruction that is induced directly by physical activity. This is because EILO is most often misdiagnosed as exercise-induced asthma (Olin et al., 2015). Failure to diagnose EILO is detrimental to those who suffer from this condition because it means a delay in proper treatments and therapies as well as a decrease in quality of life for these individuals.

Prevalence and Incidence of EILO

EILO has been known to occur in a variety of populations; however, it is most common among 20- to 40-years-olds, specifically among athletes, females, and individuals who are known to be high academic achievers (George & Suresh, 2019). Both athletes and strong academic achievers alike experience physical and/or emotional stress that may induce or worsen the symptoms associated with EILO. Although this condition is most common among young to middle-aged adults, it is on the rise among the pediatric and adolescent populations; in fact, one study estimates that as many as 35% of people with EILO are children with a median age of 14 (George & Suresh, 2019).

Individuals with certain conditions are also more likely to develop EILO. For example, one study that analyzed 27 subjects with EILO found that 66% of these individuals suffered from laryngopharyngeal reflux disease (George & Suresh, 2019). EILO is also common among those who suffer from asthma and/or post nasal drip, as such conditions irritate the vocal folds and cause laryngeal sensitivity (Abdel-Hamid, 2018).

Christensen, Thomsen, Rasmussen, and Backer (2011) found that in an unselected population in Copenhagen, 7.5% of young people suffer from EILO. Another study performed in Scandinavia predicted that 5-7% of adolescents suffer from EILO (Price, Darville, Allen, & Hull, 2017). Even though these findings are from European countries, professionals in the United States should not disregard these statistics. The prevalence of EILO in Europe and other parts of the world demonstrate that it is not as rare as was previously assumed by the medical community. The fact that a significant percentage of individuals in other countries suffer from EILO should illustrate the need for adequate differential diagnostic techniques for medical professionals around the world.

Explaining ILO and EILO

In order to ensure the best possible treatment, it is imperative that medical professionals are able to distinguish between the different types of inducible laryngeal obstruction (ILO). All types of laryngeal obstructions have at least one inducer (Olin et al., 2015). Typically, inducible laryngeal obstruction is named and defined by whatever phenomenon causes it; for example, EILO gets its name and abbreviation from exercise which causes its symptoms to appear, as is the same in the case of emotional stress-ILO.

Medical professionals should note that not all instances of ILO are the direct result of intense exercise. Many individuals who complain of breathing difficulties experience symptoms during light exercise or periods of inactivity (Olin, 2019). This should prompt professionals to investigate inducers other than exercise. It may be tempting to assume that the cause of ILO is exercise, especially if the individual being diagnosed is female; after all, EILO is twice as common among females than males (Olin et al., 2015). Despite this, experts should keep in mind the fact that *all* types of ILO are more prevalent among females. In fact, ILO in general is three to five times more common among females than males (Olin et al., 2015). For this reason, other possible inducers such as stress, psychological factors, and allergies should be investigated as possible causes of ILO-related dyspnea.

The History of ILO and EILO

ILO has plagued individuals for centuries. The first recorded instance of ILO was reported in 1842 (Dunglison, 1842). It was not until 1869, however, that laryngoscopy was used to physically visualize ILO (MacKenzie, Cohen, Solis, & Friedberg, 1869). Despite these findings, the actual cause of ILO would not be determined until the following century. Throughout the

1800s, ILO was unnamed, undefined, and incorrectly assumed to be the direct result of a psychological ailment (Abdel-Hamid, 2018). Very little research was completed to solve the mystery of ILO during the time period between the mid-1800s to the late-1900s. Finally, in 1983, the first official name for ILO was determined: vocal cord dysfunction (VCD) (Olin et al., 2015). The curiosity surrounding this disorder was once again rekindled in the 1980s. It was during this decade that medical professionals began to recognize ILO as a cause of dyspnea that was unrelated to asthma. Medical experts also recognized that ILO is not the result of a psychological ailment and have found evidence to suggest that it has a heterogeneous etiology (Røksund, Heimdal, Olofsson, Maat, & Halvorsen, 2015). Although this certainly aided in future findings, the process of successfully diagnosing and treating ILO and EILO was far from perfect. Part of the reason for this was the fact that EILO has gone by over 40 different names since it was first discovered (Olin et al. 2015). This, of course, has made communication among researchers and clinicians very difficult since EILO did not have a single universal name in the medical community.

Difference Between EILO and Asthma

Although EILO and asthma have similar presentations on the surface, medical professionals must know how to recognize even the most minute differences between these two ailments to ensure that proper diagnosis and treatment are provided to each patient or client. Individuals who are prematurely and falsely diagnosed with asthma are often given inhaled corticosteroid treatments that fail to alleviate symptoms (Kenn & Hess, 2008). Not only does the implementation of improper treatment methods fail to alleviate symptoms, but it also may involve the introduction of unnecessary medications and/or steroids.

EILO and asthma can both result in dyspnea; however, the etiology and physiological cause of dyspnea is not the same for these two ailments. Dyspnea associated with EILO is caused by abnormal vocal fold adduction upon inspiration (and sometimes expiration) during exercise that obstructs the upper respiratory tract (Abdel-Hamid, 2018). Asthma, on the other hand, is associated with the lungs and bronchioles of the lower respiratory tract. Asthmatic symptoms are most often seen or heard during expiration as air exits the lungs. The severity of asthmatic symptoms is measured by the level of decline of forced expiratory volume (Ali, 2011). It should also be noted that the length of time that symptoms persist can also be a defining factor for accurate differential diagnosis. Symptoms associated with asthma often occur during exercise and may last for many minutes after exercise has ceased. Symptoms associated with EILO contrarily only occur during peak exercise intensities and dissipate soon after exercise has ceased (Olin et al., 2015).

Since asthma is more commonly associated with expiration, it may be tempting for medical professionals to overlook EILO as a possible diagnosis for dyspnea associated with expiration. Professionals should note, however, that although EILO is more often associated with inspiration, its symptoms can sometimes be seen upon expiration as well (Price et al., 2017). Since EILO is more common upon inspiration, medical specialists have learned to recognize the characteristic harsh-sounding stridor that often accompanies this malady (Liyanagedara et al., 2017). Individuals who have EILO do not always know how to appropriately and accurately express their symptoms to their healthcare providers. The word “wheeze” is commonly used among patients with EILO to describe their dyspnea since they do not know the more accurate word “stridor,” which describes the sound that occurs when air is forcefully pushed through an

obstructed glottis. This often misguides doctors' diagnoses because wheezing is more often associated with lower airway ailments (Olin et al., 2015).

Issues that Prevent Successful Differential Diagnosis

The reason that so many individuals suffering from EILO go undiagnosed for extended periods of time is because there are a vast number of obstacles and complications that can make differential diagnosis and research efforts difficult. As stated earlier, one reason why doctors often fail to accurately diagnose EILO in their patients is because they overestimate their patients' knowledge regarding their own symptoms (Olin et al., 2015). The medical and anatomical knowledge of most patients is relatively limited, especially in comparison to a medical doctor. Even after patient interviews may indicate a certain ailment, it is essential that medical professionals investigate further into each patient's complaints in order to verify the accuracy of his or her descriptions of symptoms.

Research and improvements in differential diagnostic techniques for EILO and asthma are also hindered because of a lack of a single universal name for this condition as discussed earlier. Even if professionals were to narrow down their searches to the most common names for this condition, there would still be three common names that one must consider when sifting through information: exercise-induced laryngeal obstruction (EILO), vocal cord dysfunction (VCD), and paradoxical vocal fold motion (PVFM). VCD is most commonly used among pulmonologists and allergists while PVFM is the more popular term for speech-language pathologists (Olin et al., 2015). Cooperative research between professionals in the medical communities and in the human service communities is far from effortless if not near impossible in some instances; after all, it is incredibly difficult to ensure that vital research published by professionals in other fields can be found because of the mere fact that there are so many different names for EILO. In this

literature review alone, four initial terms were used to research this ailment. These include "exercise-induced laryngeal obstruction," "vocal cord dysfunction," "paradoxical vocal fold motion," and "inducible laryngeal obstruction." If only one or two of these terms were used in the search process, the results may be limited and/or biased because of the fact that each term used reflects a different professional field.

Another reason that accurate differential diagnosis can be difficult is because of the vast variety of dyspnea-causing ailments that exist. The most common cause of dyspnea is asthma; however, it is imperative that medical specialists also investigate other possible causes of this symptom. Aside from asthma, the additional common causes of dyspnea are EILO, musculoskeletal conditions, iron deficiencies, infectious diseases, and anemia (Smoglia, Mohseni, Berwager, & Hegedus, 2016). There also exists a multitude of other less common ailments and conditions that may cause dyspnea that medical professionals must at least consider. Since there are so many possible causes of dyspnea, it can be difficult for specialists to even know where to begin their evaluations and diagnostic procedures. It is also more likely that a wrong diagnosis can be made because of the fact that there are so many different ailments that cause this one symptom.

There are a variety of differential diagnostic techniques that professionals can use to determine the exact cause of an individual's dyspnea. Although this is beneficial to both patients and the medical community, the various types of diagnostic techniques available also demonstrate the multitude of possible causes of dyspnea. In this way, the vast amounts of diagnostic techniques may also hinder one's ability to come to an accurate diagnosis in a timely manner. Even if a cause of a patient's dyspnea is determined, professionals must remember that

it is possible for multiple conditions to coexist; for example, it is estimated that approximately 3-5% of individuals with asthma also suffer from EILO (Kenn & Hess, 2008).

Even when asthma is determined not to be the cause of an individual's dyspnea, correctly diagnosing him or her with EILO can still be a complicated task. One reason why EILO is so difficult to diagnose is because an attack typically only lasts for one or two minutes (Kenn & Hess, 2008). This does not offer a large window of time for professionals to catch, monitor, and examine an attack in action. Otolaryngologists and speech-language pathologists often use a device called a laryngoscope to examine a patient's vocal folds; however, until fairly recently laryngoscopy was not performed until after a patient had finished exercising (Olin, 2019). By this time, of course, an attack would have finished or would be just about to finish. This method of laryngoscopy is also flawed because an individual may still be feeling out of breath immediately after exercise even if an EILO attack has ceased. Performing laryngoscopy while an individual is in this state may cause the vocal folds to respond with abnormal movements that can lead to incorrect diagnoses (Olin, 2019).

Differential diagnosis between EILO and other ailments presenting with similar symptoms is hindered by the fact that EILO is a phenomenon that is relatively new to the research community. Cases of EILO were recorded in the 1800s, but at that time this malady was not fully understood. Accurate and meaningful research regarding EILO did not start appearing until the 1980s (Olin et al., 2015). This means that the condition has only been thoroughly studied for 40 years at most. Four decades may seem like a long time to learn about a condition and discover its etiologies, but the fact of the matter is that the other obstacles discussed in this literature review have greatly slowed research efforts to learn more about EILO.

Consequences of Improper Corticosteroid Use

As discussed throughout this literature review, EILO is commonly misdiagnosed as asthma. This means that improper and often ineffective treatment is given in an attempt to lessen the severity of symptoms for an ailment that is not present. In an attempt to treat asthma, many medical professionals prescribe inhaled corticosteroids. Inhaled corticosteroids are effective in minimizing the severity of dyspnea caused by asthma by delivering a high concentration of drugs directly into the air way to the lungs and bronchioles (Çil et al., 2019); however, corticosteroids do not lessen dyspnea related to EILO because they cannot prevent the vocal folds from adducting inappropriately. For this reason, EILO is often referred to as "steroid-resistant asthma" (Olin, 2019).

Before prematurely prescribing inhaled corticosteroids to individuals complaining of dyspnea, medical professionals should be aware of the detrimental side effects that may accompany these drugs if they are used improperly or unnecessarily. When unnecessary or high doses of corticosteroids are introduced into the airway, an individual is more likely to experience side effects. Inappropriate administration of corticosteroids over an extended period of time has been known to reduce the amount of mast cells within the mucosa lining of the airway which in turn decreases the body's ability to immediately react to the drug during exercise or after exposure to allergens (Roland, Bhalla, & Earis, 2004). Misusing steroids of any kind may also lead to or cause osteoporosis, glaucoma, adrenocortical suppression, and bruising (Roland et al., 2004). Some mild but aggravating symptoms may arise, such as pharyngeal discomfort and hoarseness (Roland et al., 2004). It is also possible for inhaled corticosteroids to worsen symptoms associated with EILO because they can cause laryngeal candidiasis, a fungal infection that affects the vocal folds Roland et al., 2004). They may also worsen other laryngeal-related

disorders by initiating the body's cough reflex, which irritates the pharyngolaryngeal mucosa (Roland et al., 2004). Medical professionals should note that up to 80% of each dose of an inhaled corticosteroid may be deposited on the pharyngolaryngeal mucosa instead of coursing directly to the lungs (Roland et al., 2004). For these reasons, even if an individual has asthma he or she should also be checked for EILO before being prescribed an inhaled corticosteroid in order to ensure that the benefits of any treatment will outweigh the possible side effects. The mere fact that the wrongful prescription of a drug used to treat asthma can be detrimental to an individual's body only serves to further demonstrate a dire need for more precise differential diagnostic techniques between asthma and EILO.

Differential Diagnostic Techniques

There are a variety of techniques that medical professionals can use to ensure accurate differential diagnosis between EILO and other ailments with similar presenting symptoms, namely asthma. Some of the most common methods used to diagnose EILO include the use of clinical history alone, ultrasound-based approaches, and pre- and post- laryngoscopy (Olin, 2019). Laryngoscopy is arguably the most effective differential diagnostic technique that a medical professional can use to accurately study and diagnose EILO. In this procedure, a laryngoscope is placed into an individual's mouth or nose and is then moved down into the upper respiratory tract until it reaches the larynx. This allows speech-language pathologists, otolaryngologists, and other professionals to have a clear and direct view of the vocal folds in motion. The problem with pre- and post- laryngoscopy, however, is that these methods do not provide a visual picture of the vocal folds in motion during exercise for professionals and their patients or clients (Olin, 2019). For this reason, many speech-language pathologists and medical professionals have switched to using the more accurate method of laryngoscopy known as

continuous laryngoscopy during exercise. During continuous laryngoscopy, the laryngoscope is inserted before a monitored exercise session and it remains in place throughout said session (Olin, 2019). This is especially advantageous to the process of differential diagnosis because it allows professionals to look for laryngeal obstruction in the presence of one of its most common inducers - exercise. If the larynx seems to close or narrow due to inappropriate vocal fold adduction during continuous laryngoscopy, professionals can then rule EILO as the cause of an individual's dyspnea.

As noted earlier, EILO and asthma can sometimes coexist and may both contribute to a client's complaint of dyspnea. To rule out the presence of asthma in individuals with EILO, medical professionals should also perform pulmonary function tests. According to a study by George and Suresh (2019), pulmonary function tests performed on 27 non-asthmatic individuals during an EILO attack showed that each individual had a decrease in their maximal inspiratory flow rates; however, their maximum expiratory flow rates remained stagnant (George & Suresh, 2019). A pulmonary function test with these results is consistent with a diagnosis of EILO which is strongly associated with difficulties upon inhalation. If there is ever a decrease in the maximum expiratory flow rate during a pulmonary function test doctors would have reason to suspect asthma as a potential cause of dyspnea (Ali, 2011).

There are a variety of direct and indirect tests that can be used to diagnose asthma alone. One common direct test that is useful in diagnosing asthma involves the drug methacholine (Ali, 2011). In this test, methacholine is administered into an individual's airway. This drug allows medical professionals to examine airway sensitivity (Ali, 2011). Doctors can determine that an individual has asthma if there is a presence of noticeable irritation in the lower respiratory tract (i.e. coughing or wheezing) (Ali, 2011).

An indirect test that is commonly used to discover the presence of asthma involves medical professionals recreating scenarios that trigger dyspnea in their patients or clients; for example, if dyspnea is triggered by running in the cold, an individual's forced expiratory volume may be measured directly after he or she runs in a cold climate (Ali, 2011). This type of test not only aids medical experts in making a diagnosis, but also helps them to determine the severity of the asthma if it is present (Ali, 2011).

Interventions, Therapies, and Treatments

Since the 1980s, a large multitude of successful interventions, therapies, and treatments for EILO have been studied and implemented. These interventions range from simple, noninvasive techniques to surgical operations. The type of treatment that an individual receives depends on the severity of symptoms and the medical professional implementing the intervention. Professionals from different but related fields may collaborate to create the most effective treatment plans (Abdel-Hamid, 2018). It is also common for a variety of intervention techniques to be combined to make a single and unique treatment plan.

Most medical professionals, speech-language pathologists, and various therapists will initially try to treat EILO with conservative techniques. These types of interventions include breathing techniques, desensitization techniques, biofeedback, attention training, and psychotherapy (Olin et al., 2015). The most common intervention used to treat EILO is speech therapy, which is provided by speech-language pathologists (Abdel-Hamid, 2018). The reason that speech therapy is the most common source of treatment for individuals with EILO is because it is a noninvasive technique and it is highly effective in reducing symptoms associated with EILO; in fact, one study has suggested that speech therapy is approximately 95% effective in reducing the severity of EILO-related symptoms among female athletes (Abdel-Hamid, 2018).

This type of therapy reduces EILO symptoms by retraining the respiratory tract to place less emphasis on laryngeal breathing (also known as clavicular breathing) and more emphasis on diaphragmatic breathing (Chiang et al., 2008). Aside from speech therapy, speech-language pathologists also provide breathing therapy to lessen the severity of EILO symptoms (Olin et al., 2015). The way in which an individual manipulates his or her breath can help to prevent an attack of EILO. One of these techniques is known as pursed lip breathing. This breathing technique encourages vocal fold abduction upon inspiration, which counteracts the vocal folds' initial response to adduct during an attack of EILO (Olin et al., 2015).

Although EILO was believed to be nothing more than a psychological ailment during the 18th century, modern medical professionals and researchers now know this to be false; however, this does not mean that psychological ailments do not worsen the symptoms associated with EILO. In one study which examined 27 subjects with EILO, 48% of these individuals demonstrated symptoms of an anxiety disorder (George & Suresh, 2019). For this reason, antidepressants are commonly prescribed as part of a treatment plan for EILO. Since psychological distress can worsen EILO-related dyspnea, it is essential that professionals and therapists work to treat any underlying psychological ailments that may contribute to high stress levels within each patient or client.

It should be noted that medications are not the only treatments that can be used to treat the psychological aspects of EILO. There are a variety of psychological interventions that can treat the emotional co-morbidities that often accompany EILO including psychotherapy, hypnotherapy, and cognitive-behavioral therapy (Olin et al., 2015). In themselves, psychological interventions do not work to treat EILO directly; instead, they target stressors and teach individuals how to cope with anxiety and emotional stress that may worsen EILO or cause

emotional stress-ILO (Eugalani, Eatkinson, Ehosanagar, & Eguglani, 2014). Attention training may be used alongside these psychological treatments. This type of training is a meditative technique that serves to help individuals to reach a state of relaxation, which in turn encourages the muscles of the larynx to also relax (Olin et al., 2015).

Another type of intervention that medical professionals use to treat EILO and to help patients and clients to understand the condition is biofeedback techniques (Olin et al., 2015). In these types of techniques, medical professionals use physiological tests to help patients and clients monitor and understand their own symptoms; for example, doctors and therapists may use electromyography to allow their patients or clients to visually examine the tension in their muscles. These individuals can then examine the results of these tests and develop effective self-regulation techniques to relax the muscles of the larynx in order to prevent an attack of EILO (Olin et al., 2015).

If an individual with EILO fails to respond to conservative interventions, then he or she may be treated with a surgical operation. One highly effective surgery that has been performed to treat EILO is known as laser supraglottoplasty. In a study completed by Maat et al. (2011), which consisted of 94 participants who had EILO, 23 of the participants received laser supraglottoplasty while 71 patients were treated conservatively. A follow-up questionnaire was sent to 19 of the individuals who underwent laser supraglottoplasty and to 14 of the individuals who were treated conservatively. The results of this study indicated that 16 out of the 19 individuals (or 84%) who underwent surgery claimed that their laryngeal function improved and normalized postoperatively, while only 3 of the 14 individuals (or 21%) who were treated with conservative interventions experienced significant improvement in their EILO symptoms (Maat et al., 2011).

Another study which consisted of 17 subjects with EILO used a visual analogue scale to monitor each client's progress after receiving supraglottoplasty (Mehulm, 2016). The visual analogue scale (VAS) ranged from 0-100, with 0 representing a complete absence of EILO-related symptoms and 100 representing profound symptoms (Mehulm, 2016). Prior to receiving the operation, the median VAS score given by the participants was 80; however, this median score drastically decreased to 20 after the surgery (Mehulm, 2016). These studies demonstrate that surgical treatments, although seemingly drastic, may be highly effective in treating EILO and in improving an individual's quality of life; however, since it is a medical procedure this type of treatment does come with risks. For this reason, many medical professionals only recommend supraglottoplasty to individuals who are highly active and who possess a high motivation for treatment, as these are the individuals who are most likely to benefit and improve (Mehulm, 2016).

Literary Analysis

EILO is still a relatively new and often unrecognized ailment within the research, medical, and therapeutic communities. This ailment was not accurately understood until the 1980s. Over the last four decades, professionals in a variety of fields have made crucial discoveries and have tested numerous techniques to accurately diagnose EILO. A large multitude of effective treatments have been discovered by means of experimentation and case studies. Despite the fact that knowledge regarding this ailment has vastly improved, it would be naive to assume that there is nothing left to learn about EILO and how to accurately differentiate this ailment from other similar maladies, namely asthma. Countless individuals with EILO are misdiagnosed with asthma and do not receive the proper diagnosis and treatment for a considerable amount of time; in fact, one study predicted that in 2007 approximately 40% of 22 million people diagnosed with asthma (or 8 million people) actually suffer from EILO (NHLBI Health Information Center, 2007). This fact alone should encourage professionals across various fields to continue to study EILO and to find ways to accurately diagnose this condition. The future of EILO and whether or not it will be more accurately diagnosed is dependent on cooperation between various medical professionals and their patients or clients.

The Future of EILO for Researchers

There is still much to be learned about EILO and how to accurately diagnose and effectively treat it. This, of course, means that the continuation of research and case studies are essential in order to further develop knowledge about this condition and the individuals affected by it. After 40 years of meaningful research, individuals with EILO are still incorrectly diagnosed with asthma. Perhaps this should encourage researchers to explore the possibility of a

communication barrier amongst each other and medical professionals that could be hindering successful diagnosis and treatment.

One barrier that researchers face amongst each other is that they have yet to agree on a common term for EILO. Some researchers refer to this ailment as "vocal cord dysfunction," while others know it as "paradoxical vocal fold motion." These are only two of the many aliases that EILO goes by. As a result of the vast number of terms that exist for this one condition, it is often difficult for researchers to examine the work of others in different fields. This, in turn, makes cooperation between researchers of other fields very difficult if not impossible. It should also be noted that a lack of a common name for EILO makes it difficult for individuals with this condition to learn about it. These individuals may only know EILO by one particular name; as a result, they wouldn't know to search for its other aliases and may miss out on valuable information. Little progress can be made in the research setting if researchers do not agree on a common term.

In order to accelerate the process of making new discoveries regarding effective diagnostic and treatment techniques for EILO, researchers must learn to communicate with each other in a more effective manner. This begins with agreeing on a common term. Olin et al (2015) has suggested that researchers settle on the term "exercise-induced laryngeal obstruction," as this term is highly specific and identifies the inducer of this condition. If researchers can agree to use this term in their investigations, then it will simplify the communication process within the field. Researchers will be less likely to miss important information published by others in different fields because now all researchers will use a single common name in their studies.

The Future of EILO for Speech-Language Pathologists

EILO is commonly treated by speech-language pathologists; however, proper treatment only occurs after successful diagnoses are made. Although many speech-language pathologists have access to laryngoscopes, there is a variety of medical equipment that is only available to medical professionals in hospitals. For this reason, it is essential that speech-language pathologists listen to their clients' complaints and collaborate with medical professionals to ensure that any and all diagnoses are accurate. A speech-language pathologist may be able to monitor the vocal folds while an individual is in a relatively inactive state, but continuous laryngoscopy during exercise is typically performed by an otolaryngologist. For this reason, speech-language pathologists should refer individuals to an otolaryngologist if they suspect their clients have EILO.

The treatment options that speech-language pathologists provide for EILO are conservative and non-invasive. The therapies that they provide are beneficial to individuals who do not qualify for a laser supraglottoplasty and carry no risk to said individuals. Although many professionals believe that surgical treatments are the best options for EILO, the significance of speech and breathing treatments that are provided by speech-language pathologists should not be forgotten. These types of therapies are known to significantly reduce dyspnea related to EILO by retraining the vocal folds and larynx during aerobic exercises and breathing (Olin et al., 2015).

Finally, speech-language pathologists should maintain a sense of curiosity when it comes to exploring therapy options for EILO as well as a desire to improve upon current research. Over the past 40 years, researchers have discovered copious diagnostic and treatment techniques for EILO. These techniques have improved throughout time and can only continue to do so in the

presence of genuine curiosity and a thirst to discover more solutions. Speech-language pathologists have vastly improved the quality of life for many individuals with EILO; therefore, they should continue to find new ways to change their client's lives for the better.

The Future of EILO for Medical Professionals

Medical professionals are responsible for accurately diagnosing every patient that they see. Unfortunately, many of these professionals are unable to do so for individuals with EILO-related dyspnea. Doctors feel more inclined to test their patients for more common causes of dyspnea such as asthma or allergies. They often overlook EILO as a possibility as there is currently less available information and knowledge on this malady than on asthma and other better-known conditions (Smoglia et al., 2016).

There are a variety of steps that medical professionals can take to ensure that more patients receive the correct diagnosis upon their first visit. First, medical professionals should be mindful of any and all possible causes of dyspnea. Even if EILO is not initially suspected, otolaryngologists should still perform a laryngoscopy to be certain and confident in their diagnoses. It should also be noted that EILO and asthma commonly coexist; therefore, it would be beneficial for doctors to perform both pulmonary function tests and laryngoscopy on patients who complain of dyspnea.

Doctors should also listen objectively during patient interviews and avoid the assumption that the patients' descriptions are completely accurate. Most people have limited knowledge of medical maladies, especially when compared to the medical professionals caring for them. This, in turn, may result in inaccurate use of vocabulary that could mislead diagnosis; for example, many patients with EILO describe their dyspnea as a "wheeze" when they really mean "stridor"

(Olin et al., 2015). This often leads medical professionals to assume that these patients are suffering from an ailment of the lower airway when in fact the problem exists in the larynx.

Accurate differential diagnosis by medical professionals is vital to the health of their patients. An incorrect diagnosis can delay advantageous treatment or may involve prescribing unnecessary medications or treatments. One common treatment option that is often automatically provided by healthcare professionals are inhaled corticosteroids. Inhaled corticosteroids are highly effective in reducing dyspnea for individuals suffering from asthma; however, they provide little to no benefit and often cause adverse effects in individuals with EILO. Medical professionals have a duty to care for their patients to the best of their abilities. This includes weighing all possible diagnoses before prematurely prescribing any medications.

The Future of EILO for Affected Individuals

EILO can be distressing for the individuals that it affects. It is associated with shortness of breath that can sometimes be severe and panic-inducing. Individuals affected by this condition are often misdiagnosed with asthma and do not receive the proper treatments for considerable amounts of time. In a world where research strategies are flawed and medicine is imperfect, there are steps that every individual affected by EILO can take to assist themselves.

It is essential that individuals educate themselves about EILO. Although this condition is not as uncommon as previously suspected, most people are unaware that it even exists. Researching EILO and examining one's own symptoms may be imperative in ensuring accurate diagnosis. Having knowledge on EILO can also assist individuals in effectively communicating their symptoms to healthcare providers. While researching EILO, individuals should also be mindful of its numerous aliases. In order to broaden their understanding of this condition, those

affected by EILO should explore a multitude of aliases and compare information from professionals in different fields.

Finally, individuals suffering from dyspnea must monitor their progress during treatment. Effective treatment should result in diminished symptoms and improved quality of life. If treatment does not cause improvement or worsens symptoms, an individual should revisit his or her healthcare provider for reconsideration of diagnosis.

Conclusions

Based upon the information found in current literature, barriers to appropriate diagnosis of EILO continue to be great. There are, however, a variety of recommendations that researchers, doctors, speech-language pathologists, and individuals suffering from dyspnea alike should heed in order to improve the accuracy of diagnosis and proper administration of treatment. These include agreeing on a single term to describe EILO, improving collaboration between clinicians and doctors, implementing a universal questionnaire to improve the accuracy of diagnosis, and educating oneself on the various causes of dyspnea.

Perhaps the first step that must be taken in order to improve the accuracy of accurate diagnosis of EILO is for medical professionals and researchers of different fields to agree on a single universal term to define EILO. Olin et al. (2015) suggests that "exercise-induced laryngeal obstruction" is arguably the most accurate term to use for this condition because it describes where obstruction occurs within the respiratory tract and it identifies the specific inducer. Agreeing on the usage of the single term "exercise-induced laryngeal obstruction" may help improve research and diagnosis because it would significantly simplify the process of sharing research and knowledge between professionals of different fields.

The use of a single common term for EILO is not the only step that can ensure more accurate diagnosis of EILO. It is also critical that professionals of various fields find other ways to collaborate with each other. This includes more direct communication between doctors and clinicians. Doctors are responsible for diagnosing individuals, but clinicians are often the ones who treat the individuals' ailments and provide therapy techniques (Euglani, et al., 2014). Clinicians should closely monitor their clients' progress during therapy and/or treatment and should report their findings to each client's health care provider. Doctors would then be able to examine how well their patients are responding to treatment and/or therapy so that they can determine if they should consider another cause of dyspnea. Doctors should also take vigorous notes during examination and diagnosis of each patient to send to clinicians working with the affected individual. This would help clinicians to identify specific findings so that they can customize their treatments for each client.

The next step that should be taken to improve the accuracy of diagnosis of EILO is to create a universal questionnaire that would be provided to all individuals complaining of dyspnea. As stated earlier, doctors often make the calamitous mistake of taking their patients' descriptions too literally (Olin, et al., 2015). Doctors should keep in mind that most of their patients are not familiar with medical jargon. The implementation of a questionnaire may help patients to more accurately identify and describe their symptoms. This, in turn, would help doctors to draw more definite conclusions during the diagnostic process.

Finally, medical professionals, clinicians, and individuals suffering from dyspnea alike should explore all possible causes of dyspnea. This will teach individuals to identify significant and critical differences among similar ailments. Knowing even the most minute differences

between one ailment and another can determine whether a diagnosis will be accurate or erroneous.

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